TOXICOLOGY AND FORENSIC MEDICINE

Openventio PUBLISHERS

ISSN 2474-8978 Open Journal http://dx.doi.org/10.17140/TFMOJ-SE-1-e001

Special Edition
"Advances in Forensic Entomotoxicology"

Editorial

Corresponding author
David R. Wallace, PhD
Professor
Department of Pharmacology and Toxicology, Oklahoma State University Center for Health Sciences
Room E-367, Tulsa
OK 74107-1898, USA
Tel. +1-918-561-1407
Fax: +1-918-561-5729
E-mail: david.wallace@okstate.edu

Special Edition 1
Article Ref. #: 1000TFMOJSE1e001

Article History
Received: September 7th, 2017
Accepted: September 8th, 2017
Published: September 8th, 2017

Citation
Wallace DR. Evolution of forensic entomotoxicology. *Toxicol Forensic Med Open J*. 2017; SE(1): Se1-Se4. doi: 10.17140/TFMOJ-SE-1-e001

Evolution of Forensic Entomotoxicology

David R. Wallace, PhD*

Department of Pharmacology and Toxicology, Oklahoma State University Center for Health Sciences, Tulsa, OK 74107-1898, USA

Most individuals first think of insects when they hear the word 'entomology,' yet entomology is a much broader topic involved with the study of multiple organisms such as millipedes, centipedes, arachnids and other insects as well as crustaceans (collectively referred to as arthropods). The forensic application is how these organisms can be used in legal investigations. Most often, forensic entomology deals with feeding insects which aid in determining the time of death, but there is more information that can be collected from the action of insects on dead and decaying flesh. Subsets of the forensic entomology field can be subdivided into three subsets: urban, stored product and medico-legal.[1] The beginnings of forensic entomology can be traced back to the 1200's in China, with Sung Tzu as the 'first' forensic entomologist. Other notable forensic entomologists have been Francesco Redi (1600's), Bergert d'Arbois (1800's) and Hermann Reinhard (late 1800's). Key advancements in forensic entomology have only happened over the last 150 years. A significant amount of work has been submitted by Reinhard and Hofmann in the late 1800's in Germany and France, respectively.[2] Initially, arthropods were valued for their ability to assist in determining the postmortem interval. Later, arthropod use became valuable in determining the cause of death due to the presence of drugs or poisoning.[2] The ability of arthropods to help define the time of death is astounding.[3,4] Conventional measurements such as body temperature and rigor are only accurate for a couple of days and are significantly altered due to differences in ambient temperature. The growth cycle of the blowfly (the larvae phase being maggots) is highly consistent, and as one of the first inhabitants of a cadaver, the stage of blowfly development can be back calculated to determine with a high level of accuracy, time of death.[2,5,6] The site where the death occurred has an enormous impact on the types of arthropod infestations which would be specific to the location of the cadaver and various arthropods have been examined based on their specificity in gauging time, and place of death.[7-11] In addition to arthropods, the use of fungi has also been utilized to aid in determining postmortem interval and location of death.[12] In the last decade, concerted efforts have been made to establish uniform guidelines for the practice of forensic entomology and define a series of best practices that can be utilized by any laboratory.[13]

Over the last hundred years, as forensic entomology has evolved, a new field has developed-forensic entomotoxicology. Entomotoxicology investigates for the presence or absence of toxins or drugs in various arthropods (primarily flies and beetles).[14] The development of entomotoxicology has been a significant advancement in the detection and identification of drugs or toxins in bodies which have been significantly composed or burned where fluids and tissue may be at a premium.[15] Using pharmacological and toxicological principles such as absorption, distribution, metabolism, elimination, and toxicology, the actions of drugs or poisons on arthropods can be an invaluable tool in aiding the determination of cause and time of death.[5,16] There are two aspects of forensic entomotoxicology that have demonstrated high value. First is the estimation of postmortem interval and second is the identification or quantification of drugs in a body. Various illicit drugs (opioids and psychostimulants) can alter the growth and development rates of both flies and beetles. Investigators have studied the effects of drugs such as ketamine, morphine, and diazepam on the growth and development of larvae of different arthropods, Diptera: Calliphoridae in particular.[17-19] Examination of larvae growth and development is not restricted to only drugs, but also the analysis of pesticide action.[20] By identifying the drug which is present, and following the arthropod growth cycle, a more accurate determination of the time of death can be estimated. In some instances, entomotoxicology is a two-step process where simple examination for the presence of a drug is not enough. Common-

ISSN 2474-8978 http://dx.doi.org/10.17140/TFMOJ-SE-1-e001

ly, beetles (Order: Coleoptera) and their feces are used in entomotoxicology for the detection of drugs and other toxins. The presence of particular drugs is often the result of the beetles' feeding on fly larvae (Order: Diptera) that had previously been consuming the dead flesh that contained the toxic substances in a manner analogous to a food chain. Studies investigating arthropod pharmacokinetics (absorption, distribution, metabolism, and elimination) are needed since evidence for drug effects in insects is lacking.[5,16] The difficulty in detecting drugs in larvae is a primary reason this area of research has lagged in development. Detection can only occur when the rate of absorption exceeds the rate of elimination and there have been reports that some drugs will not bioaccumulate over the entire life-cycle of the larvae, suggesting different pharmacokinetic characteristics across different arthropods.[14] Although, our understanding of drug actions in humans is extensive, there is relatively little work on how drugs (heroin and methamphetamine) are metabolized in insects, which may confound later interpretations.[15] Due to the significant variability in detectable drug quantities, it is best to sample only the larvae that are actively feeding.[21] The premise of sampling only feeding larvae suggests that there is some degree of drug or toxin elimination from the larvae's system over time.[22] Also, toxins contained in tissues fed upon by carrion insects, have the potential for altering developmental patterns of arthropods and so the pos tmortem interval is also altered. A recent report has attempted to account for these development changes by measuring the quantity of volatile gas that is released.[23] By assessing the volatile organics that are being released by the arthropods, this will aid in adjusting for any postmortem interval alterations induced by other drugs. So, it is important to continue studying how different toxins can affect the development and other parameters of insects of forensic importance.[15] In some instances, our ability to detect and identify is constricted by the available technology. The 'gold standard' for confirmatory tests has been the use of gas chromatography with mass spectrometry (GC/MS). In fact, there are confirmatory tests for the determination of nicotine and methamphetamine in *Calliphora vomitoria*.[24,25] However, the need has arisen for testing methods that are not sample-destructive. Oliveira et al have examined the use of near-infrared spectroscopy to detect and quantify the levels of benzodiazepines in *Chrysomya megacephala* in a non-destructive manner.[26] Another method utilizes mass spectrometry for detection, but liquid chromatography as the carrier system has been shown to be efficacious in the detection and quantification of Δ^9-tetrahydrocannabinol in blowfly larvae.[27] It is apparent that as our technology advances, the methods for detection and quantification of drugs, pesticides and toxin/toxicants in arthropods will become more accurate and sensitive. More work is needed for the further advancement of entomotoxicology.

SUMMARY

Forensic entomology and more specifically, forensic entomotoxicology, is a new and evolving discipline. Although, evidence has existed for decades, only recently has there been a concerted effort to formalize the methods and guidelines for entomotoxicology as a stand-alone discipline. By incorporating the features of entomology and toxicology, entomotoxicology is poised to be one of the newest, and exciting, fields of forensic science. The intent of this special edition is to highlight the existing work in the field of entomotoxicology and shed light on the additional work that is needed.

CONFLICTS OF INTEREST

The author declares that there is no conflicts of interest.

REFERENCES

1. Forensic entomology. 2017. Web site. https://en.wikipedia.org/wiki/Forensic_entomology#cite_note-2. Accessed August 29, 2017.

2. Benecke M. A brief history of forensic entomology. *Forensic Sci Int*. 2001; 120(1-2): 2-14. doi: 10.1016/S0379-0738(01)00409-1

3. Marchenko MI. Medicolegal relevance of cadaver entomofauna for the determination of the time of death. *Forensic Sci Int*. 2001; 120(1-2): 89-109. doi: 10.1016/S0379-0738(01)00416-9

4. Arnaldos M, Romera E, Presa J, Luna A. Estimation of postmortem interval in real cases based on experimentally obtained entomological evidence. *Forensic Sci Int*. 2005; 149(1): 57-65. doi: 10.1016/j.forsciint.2004.04.087

5. Amendt J, Krettek R, Zehner R. Forensic entomology. *Naturwissenschaften*. 2004; 91(2): 51-65. doi: 10.1007/s00114-003-0493-5

6. Campobasso CP, Introna F. The forensic entomologist in the context of the forensic pathologist's role. *Forensic Sci Int*. 2001; 120(1-2): 132-139. doi: 10.1016/S0379-0738(01)00425-X

7. Wolff M, Uribe A, Ortiz A, Duque P. A preliminary study of forensic entomology in Medellin, Colombia. *Forensic Sci Int*.

ISSN 2474-8978 http://dx.doi.org/10.17140/TFMOJ-SE-1-e001

2001;120(1-2): 53-59. doi: 10.1016/S0379-0738(01)00422-4

8. Kulshrestha P, Satpathy DK. Use of beetles in forensic entomology. *Forensic Sci Int*. 2001; 120(1-2): 15-17. doi: 10.1016/S0379-0738(01)00410-8

9. Sharma R, Garg RK, Gaur J. Various methods for the estimation of the postmortem interval from Calliphoridae: A review. *Egypt J Forensic Sci*. 2015; 5(1): 1-12. doi: 10.1016/j.ejfs.2013.04.002

10. Musvasva E, Williams KA, Muller WJ, Villet MH. Preliminary observations on the effects of hydrocortisone and sodium methohexital on development of Sarcophaga (Curranea) tibialis Macquart (Diptera: Sarcophagidae), and implications for estimating postmortem interval. *Forensic Sci Int*. 2001; 120(1-2): 37-41. doi: 1016/S0379-0738(01)00415-7

11. Myskowiak J-B, Doums C. Effects of refrigeration on the biometry and development of Protophormia terraenovae (Robineau–Desvoidy) (Diptera: Calliphoridae) and its consequences in estimating post-mortem interval in forensic investigations. *Forensic Sci Int*. 2002; 125(2-3): 254-261. doi: 10.1016/S0379-0738(02)00003-8

12. Hitosugi M, Ishii K, Yaguchi T, et al. Fungi can be a useful forensic tool. *Leg Med*. 2006; 8(4): 240-242. doi: 10.1016/j.legalmed.2006.04.005

13. Amendt J, Campobasso CP, Gaudry E, Reiter C, LeBlanc HN, Hall MJR. Best practice in forensic entomology—standards and guidelines. *Int J Leg Med*. 2007; 121: 90-104. doi: 10.1007/s00414-006-0086-x

14. Introna F, Pietro Campobasso C, Lee Goff M. Entomotoxicology. *Forensic Sci Int*. 2001; 120(1-2): 42-47. doi: 10.1016/S0379-0738(01)00418-2

15. Gosselin M, Wille SMR, Del Mar M, et al. Entomotoxicology, experimental set-up and interpretation for forensic toxicologists. *Forensic Sci Int*. 2011; 208: 1-9. doi: 10.1016/j.forsciint.2010.12.015

16. Gautam L, Pathak R, Danlami HS, Cole MD. Entomotoxicology: Alternative Matrices for Forensic Toxicology. Forensic Magazine. 2013. Web site. https://www.forensicmag.com/article/2013/08/entomotoxicology-alternative-matrices-forensic-toxicology. Accessed September 1, 2017.

17. Zou Y, Huang M, Huang R, et al. Effect of ketamine on the development of Lucilia sericata (Meigen) (Diptera: Calliphoridae) and preliminary pathological observation of larvae. *Forensic Sci Int*. 2013; 226(1-3): 273-281. doi: 10.1016/j.forsciint.2013.01.042

18. George KA, Archer MS, Green LM, Conlan XA, Toop T. Effect of morphine on the growth rate of Calliphora stygia (Fabricius) (Diptera: Calliphoridae) and possible implications for forensic entomology. *Forensic Sci Int*. 2009; 193(1-3): 21-25. doi: 10.1016/j.forsciint.2009.08.013

19. Carvalho LML, Linhares AX, Trigo JR. Determination of drug levels and the effect of diazepam on the growth of necrophagous flies of forensic importance in southeastern Brazil. *Forensic Sci Int*. 2001; 120(1-2): 140-144. doi: 10.1016/S0379-0738(01)00421-2

20. Liu X, Shi Y, Wang H, Zhang RJ. Determination of Malathion levels and its effect on the development of Chrysomya megacephala (Fabricius) in South China. *Forensic Sci Int*. 2009; 192(1-3): 14-18. doi: 10.1016/j.forsciint.2009.07.005

21. Sadler DW, Fuke C, Court F, Pounder DJ. Drug accumulation and elimination in Calliphora vicina larvae. *Forensic Sci Int*. 1995; 71(3): 191-197. doi: 10.1016/0379-0738(94)01663-1

22. Gagliano-Candela R, Aventaggiato L. The detection of toxic substances in entomological specimens. *Int J Leg Med*. 2001; 114(4-5): 197-203. doi: 10.1007/s004140000181

23. Frederickx C, Dekeirsschieter J, Brostaux Y, Wathelet JP, Verheggen FJ, Haubruge E. Volatile organic compounds released by blowfly larvae and pupae: New perspectives in forensic entomology. *Forensic Sci Int*. 2012; 219(1-3): 215-220. doi: 10.1016/j.forsciint.2012.01.007

24. Magni PA, Pazzi M, Vincenti M, Alladio E, Brandimarte M, Dadour IR. Development and validation of a GC-MS method

ISSN 2474-8978 http://dx.doi.org/10.17140/TFMOJ-SE-1-e001

for nicotine detection in Calliphora vomitoria (L.) (Diptera: Calliphoridae). *Forensic Sci Int*. 2016; 261: 53-60. doi: 10.1016/j.forsciint.2015.11.014

25. Magni PA, Pacini T, Pazzi M, Vincenti M, Dadour IR. Development of a GC-MS method for methamphetamine detection in Calliphora vomitoria L. (Diptera: Calliphoridae). *Forensic Sci Int*. 2014; 241: 96-101. doi: 10.1016/j.forsciint.2014.05.004

26. Oliveira JS, Baia TC, Gama RA, Lima KMG. Development of a novel non-destructive method based on spectral fingerprint for determination of abused drug in insects: An alternative entomotoxicology approach. *Microchem J*. 2014; 115: 39-46. doi: 10.1016/j.microc.2014.02.009

27. Karampela S, Pistos C, Moraitis K, et al. Development and validation of a LC/MS method for the determination of Delta-9-tetrahydrocannabinol and 11-carboxy-Delta-9-tetrahydrocannabinol in the larvae of the blowfly Lucilia sericata: Forensic applications. *Sci Justice*. 2015; 55(6): 472-480. doi: 10.1016/j.scijus.2015.06.003